LIBRARY
FISH & WILDLIFE SERVICE
PACIFIC OCEANIC FISHERY
INVESTIGATIONS

VOLUME IX OCTOBER-DECEMBER, 1934 No. 4

JOURNAL

OF THE

Pan-Pacific Research Institution

A Periodical Record of Investigations Bearing on Problems of Food Production, Distribution, Conservation and Consumption, as well as on Public Health, and Race and Population Problems as Related to the Countries Bordering on the Pacific.

INDEX

The Reef Liparid Fishes Inhabiting the West Coast of the United States - - - - - - - - - - 2
By Carl L. Hubbs and Leonard P. Schultz

Stability of Land and Water Areas in the Southwest Pacific - 7
By P. Marshall, M.A., D.Sc.

Production of Honey in Hawaii - - - - - - - - - - 15

AT PRESENT PUBLISHED QUARTERLY AT HONOLULU, HAWAII
BY THE
PAN-PACIFIC UNION

More frequent publication as acceptable material is contributed.

The Reef Liparid Fishes Inhabiting the West Coast of the United States

By CARL L. HUBBS and LEONARD P. SCHULTZ
University of Michigan and University of Washington

The publication of Victor Burke's 1930 "Revision of the fishes of the family Liparidae" fills a long-felt want, and makes it possible for us to treat the four species which we have collected on the rocky shores of the western United States, Washington, Oregon, and California. One of the species, which we identify with *Liparis mucosus* Ayres, has previously been definitely known only from San Francisco, but we have specimens from Pacific Grove, California, and from northern Washington. The ranges of the three other species are extended to the southward distances varying from a few miles to several hundred miles. *Liparis rutteri* is recorded for the first time from Washington and Oregon and *Liparis fucensis* for the first time from Oregon and California. Having material apparently representing the true *mucosus*, we are able to revalidate *Liparis florae* (Jordan and Starks), and that species we show to be the common reef species of the West Coast. The life colors of all four species are described. Three of the species, *rutteri, mucosus,* and *fucensis,* are added to the list of those developing at times a striped color phase, while *florae* (Burke's *mucosus*) is abstracted from this list.

1. *Liparis rutteri* (Gilbert and Snyder)

Of this very well-marked species previously "known from the southeast coast of Alaska and the Aleutian Islands" (Burke, 1930) and from "Ucluelet", Vancouver Island (Bean and Weed, 1920) we took a considerable number of specimens in rocky tide-pools between Cape Johnson in northern Washington and Cape Arago in southern Oregon. It is locally not extremely rare in the lower tide-pools; in some places it is fairly common in stony or bouldery tide-pools.

We make the identification of our material with *rutteri* on the basis of Evermann and Goldsborough's (1907: 333, fig. 99) and Burke's (1930: 61) accounts, for the agreement is complete. None of our specimens show the separated and elevated first dorsal rays as described for the three types (Gilbert and Snyder, in Jordan and Evermann, 1898: 2108).

This species exists in two chief color phases, which we have taken together in the same tide-pool. One phase, figured by Evermann and Goldsborough, is uniformly dark, usually blackish, abruptly broken by a light gray bar across caudal base and on posterior margins of dorsal and anal fins. In the other chief color phase, which has not been described, and appears to be the less common, the body is marked by the bold wavy stripes which many of the species of *Liparis* show more or less frequently, and the pale bar at the caudal base is less abrupt and distinct than in the blackish phase. This distinctive mark, however, is evident in all our specimens.

Our field records carry the following life-color descriptions, covering the two main color phases and other types.

1. Reef opposite Quillayute Needles, near La Push, Washington. Blackish green, with gray bar at base of caudal fin, which is light with irregular narrow dark bars.

2. Same reef.—Bluish gray, finely but thickly mottled with olive posteriorly; a black brown streak from origin of lateral line to angle of mouth, curved so as to pass through eye; a trace of another streak extended downward and backward from eye.

3. Cape Elizabeth, north of Taholah, Washington.—Blackish.

4. Same locality.—Greenish brown to dusky, more or less distinctly blotched, reticulated or wavily streaked with gray.

5. Point Grenville, north of Moclips, Washington.—Blackish and wavily streaked phases.

6. Cape Falcon, Oregon.—Streaked and black phases.

7. Reef between Cape Arago Light and Sunset Cove, Oregon.—Irregularly blotched with pale rosy and olive (neither color clear), darkening toward and on dorsal and anal fins, and toward white bar at base of caudal fin, which is whitish with black specks and indistinct wide subbasal dark bar; pectoral fin finely mottled with rosy and olive, becoming clear toward margin.

2. *Liparis florae* (Jordan and Starks)

This well-marked species has erroneously been synonymized with *Liparis mucosus* by Gilbert and Burke (1912: 71) and by Burke (1930: 64). The distinctive features of *mucosus* are indicated below. So far as we can judge from his account, Burke had only one specimen of the real *mucosus*—the 55 mm. specimen in striped phase and with a big disk.

Liparis florae is a common species in the tide-pools along the entire outer coast of Washington, Oregon, and the northern half of California (south to Point Lobos, Monterey County). In this habitat it generally outnumbers all the other species of liparids, and is often the only one present. We have a large number of specimens, which are very uniform in specific characters. Some, it is true, approach *Liparis micraspidophorus* in one or another of the distinctive features which Burke has pointed out (1930: 57, 64 and 66), but we do not believe that they can be referred to that species, or that *micraspidophorus* is not valid. The skin is generally less lax and distinctly more leathery than in the other West Coast species of *Liparis*, but some individuals have the skin fairly loose.

Liparis florae differs from *L. callyodon* in having the gill slit extending opposite 3 to 5 pectoral rays instead of ending above the first pectoral ray; first dorsal indented behind instead of rounded; anus slightly nearer anal fin than disk (rarely equidistant from anal and disk) instead of being much nearer disk than anal; peritoneum pale and unspotted instead of pale and spotted with black; pectoral rays 31 to 33 instead of 28 to 31; and dorsal rays 31 to 33 instead of 33 to 35.

Liparis florae is featured by its uniform coloration. It appears always to lack the striped and blotched color phases so often developed within species through the genus. The color itself is usually kelp brown, but varies from olive green to lemon yellow and through various shades of greenish brown to red brown. Occasional individuals are pale gray, pinkish gray, grayish pink, bright pink, dusky purplish or even cherry red. The young show a greater color variation than the adults, but large ones range through the whole variation indicated. Usually the fins are colored like the body, but the caudal fin and margins of dorsal and anal are reddish in some individuals otherwise greenish brown. The small rounded spots typically evident along the midline tend to be blackish brown in the greener specimens and bright red in the redder ones. These color notes are a summary of a large number of entries in our field books.

Burke (1930: 64-65) claimed that this species (his *"mucosus"*) sometimes develops a striped color phase. But we have failed to discover any striped specimen among hundreds (Burke examined but twelve). Inasmuch as Burke's one striped specimen also had the disc much too large, we assume it was the one example of the real *mucosus* which he had seen.

3. *Liparis mucosus* Ayres

Of this species we have taken only three young to half-grown specimens: two in extremely low rocky tide-pools near Cape Johnson, northern Washington, and one just below the lowest tide limits on a reef at Pacific Grove, central California. Inasmuch as we have poisoned hundreds of tide-pools along the entire West Coast, we assume from these records that the species is characteristic of the incompletely explored subtidal belt of the reefs.

One of our specimens, 31.5 mm. long to caudal, was collected on January 4, 1923, at the tip of Mussel Point, on which the Hopkins Marine Station is located, at

Pacific Grove, Monterey Bay, California. It was taken in a scraping hand net at a very low tide, on the slope of a rock, where clothed with a thick growth of various short plants, beyond the lowest tidal limits. This bright red specimen, was scraped up with a large mass of thick encrusting red sponge, which lay under a canopy of eel-grass (*Phyllospadix*).

Our largest specimen, 46 mm. long to caudal, was poisoned on the reef one and three-fourths miles southeast of Cape Johnson, near La Push, Clallam County, northern Washington, on June 29, 1926, when the low tide level of —1.3 was reached. The pool was so low on the reef as to allow a slight influx of water into the pool. It had a bottom of rock and sand, with some litter; was moderately protected from the surf, and contained much eel-grass, *Laminaria, Macrocystis* and other brown algae, and also red algae.

A young specimen, 14 mm. long to caudal, was collected with poison in a tide-pool on the reef one and a third miles southeast of Cape Johnson, Washington, on June 27, 1926, when the very low tide level of —1.7 feet was attained. The pool was so low as to suffer some ingress of waves. It had a bottom of rock, stones and gravel; was rather well protected from the surf, and contained much eel-grass and kelp and other brown algae, etc.

Our specimens trace down to *L. "mucosus"* (= *L. florae*) and *L. micraspidaphorus* in Burke's key (1930: 57). They certainly represent a species distinct from these. From *florae,* which occurs in the same region, and which Burke wrongly synonymized with *mucosus,* it differs in numerous respects: the body is heavier forward, deepest below origin of first instead of below front part of second dorsal; the disk is larger, more instead of less than half as long as head; the anus is nearer anal fin than disk, rather than the reverse; the eye is larger, 5 to 7 rather than 8 to 9 in head; the first dorsal fin is low and broadly rounded, not incised behind, instead of being a high, distinct lobe; skin is distinctly less leathery but more lax; a striped color phase is often developed (never seen in *florae*); there is (in our specimens at least) a narrow blackish bar at the caudal base, not developed in *florae*; the color is probably usually brighter, typically red or lavender rather than typically yellowish brown, rarely red and apparently never lavender.

In the two features first mentioned, but only in these, *L. mucosus* agrees with *L. micraspidophorus* Gilbert and Burke (1912: 71, fig. 16), a species regarded by Burke as a far western representative of *"mucosus"* (= *florae*). It is known from Agattu and Bering Islands, about the end of the Aleutian chain.

The only other species with which *mucosus* has much in common appear to be *L. curilensis* (Gilbert and Burke) of the Kurile Islands, and *L. callyodon* (Pallas) and *L. cyclopus* Günther, which range south to northern Washington. From *curilensis* it differs at least in having fewer dorsal rays and a more deeply cleft gill-slit. From *callyodon* it differs in having fewer dorsal and anal rays, a much larger disk, and the gill slit extending down in front of 3 to 5 pectoral rays. From *L. cyclopus* it differs in having fewer dorsal and anal rays, a much larger disk and a distinct first dorsal fin. *Liparis mucosus* appears quite distinct from any of the species recently described from Siberia (see Soldatov and Lindberg, 1930).

Why Burke synonymized *florae* with *mucosus* is not apparent, as Jordan and Starks (1895) in their original description of *florae* clearly described and figured the differences between the two species. Their account seems to hold except in one point: the gill slit of *mucosus* (unless two species are confused under the name) usually extends down past several pectoral rays. The type description of *mucosus* by Ayres (1855: 22), reprinted by Günther (1861: 559), fits the species here called *mucosus* rather than *florae* in regards size of eye ("longitudinal diameter of the eye nearly one-sixth of the length of the head"); form of dorsal fin

("the dorsal is emarginate a short distance from its origin, giving in a degree the appearance of an anterior dorsal"), and in the laxity of the skin ("in the loose attachment of the skin, this species agrees well with *L. pulchellus*"). Steindachner's (1875: 82) account of *"Liparis (Neoliparis) mucosus"*, based on four specimens taken among many hundreds of *Liparis pulchellus* in San Francisco Bay, appears to have been based on true *mucosus*. Garman's account (1892: 52, plates 5, 9 and 10) of *"Liparis mucosus"* was apparently based in part on *Liparis florae*, and there is no evidence that he had the true *mucosus*. Jordan and Starks' description and figure (1895: 832, pl. 95) of a specimen from off San Francisco has already been referred to. Their account was repeated by Jordan and Evermann (1898: 2111; and 1900: 3296, pl. 315, fig. 761). Burke (1930: 64), as already mentioned, appears to have had only one specimen of the true *mucosus*.

Since this species has been so rarely taken, we offer a description of our three specimens.

Dorsal rays 30 (32)[1]; anal, 24 (25); pectoral, 30-31 (28 and 32); caudal rays 16 (16 and 17), 10 principal rays. Disc 1.7 (1.7 and 1.8) in head. Head 3.6 (3.5 and 3.8) in standard length; head and trunk, 2.5 (2.2 and 2.5) in tail; depth of body 4.1 (3.7 and 3.9); depth of head 4.7 (4.3 and 4.5). Eye 5.5 (5.8 and 6.0) in head; snout 2.9 (2.8 and 2.9). Gill-slit extending down in front of 3 to 6 pectoral rays. Dorsal with a distinct first fin of about 4 rays; less than half as high as long, and broadly joined with second fin, without any incised notch. Dorsal and anal connections with caudal very short: the dorsal membrane ends about opposite the extreme base of caudal while the anal membrane ends at the end of the skin-covered base of the fin. Prickles scarcely developed. Body heavy forward, with greatest depth below origin of dorsal fin. Anus about half length of eye nearer origin of anal fin than disk (still nearer anal in the young).

A feature of this species appears to be the blackish bar at the caudal base (at end of skin-covered area). This is the most distinct of the several dark bars across the caudal fin, and appears in all three specimens, which otherwise have little in common either in color or coloration. Fortunately, the life colors were recorded for all three specimens.

The California specimen in life was a rather bright red, clearest on the head, mixed with some dusky posteriorly. The pectoral and vertical fins were also red. The caudal was somewhat paler than the other vertical fins, and separated from the body by a more definite dusky streak. (The other bars on the caudal fin are more faint than in the other two specimens, and were not mentioned in the field notes). The pelvic disk was pale whitish, as was also the region between disk and anus. The body on close inspection showed small spots composed of melanophores and erythrophores, and showing some tendency toward alignment and grouping to form vertical dark bars, especially toward middle of body.

The larger Washington fish in general ground color was lavender, becoming grayish on middle of body but intensified to pink on outer half of dorsal and anal fins. The top of the head was chalky lavender. The body was marked by numerous fine wavy bands of olive, with pale centers. (These stripes are narrower and more numerous than in the striped specimens of *L. rutteri*.) The circular row of outer pelvic suckers was yellow.

The young example from Washington was in a similar phase: pale lavender, boldly striped with longitudinal wavy lines.

Ayres stated the color of the type of *mucosus* to be plain greenish olive, but Steindachner describes the species as "einfärbig blass rosenroth und blass röthlichviolett im Leben, selten grau am

[1] Characters in parenthesis taken from the two Washington specimens; those before the parenthesis, taken from the one California specimen at hand.

Rücken, ohne Spuren von Flecken oder einer dunkleren Marmorirung."

The variation in color pattern is paralleled within too many species of *Liparis* to appear of systematic significance. The variation in color involves only two of the color types developed by many of the tide-pool species, apparently in mimicry of the brilliant colors of the associated vegetation. The red of the type well matched that of the large mass of an encrusting sponge which was scraped off the rock with it. The lavender of the other two is the color of the coralline algae which encrusts the rocks of the tidal belt. The brighter colors of *mucosus* as compared with *florae* are probably associated with a lesser degree of restriction to the larger brown algae, especially the kelp, which *florae* usually imitates in color.

4. *Liparis fucensis* Gilbert

The identification of our material with *fucensis* is made on the assumption that Gilbert and Thompson (1905: 983) and Burke (1930: 71) were right in synonymizing *Neoliparis fissuratus* Starks (1896: 560) with *Liparis fucensis* Gilbert (1896: 447). The original accounts of the two nominal species were repeated by Jordan and Evermann (1898: 2113 and 2119). Nearly all of our specimens have the first dorsal somewhat elevated and with the rays somewhat free.

The distribution of *fucensis* is given by Burke as "coast of Washington and southeastern Alaska." We have taken it, however, at numerous points along the open-coast reefs from northern Washington through Oregon to near Crescent City, northern California. All our specimens are from rock-pools, and all are young to half-grown. The adults probably inhabit deeper water.

This species, like so many in the genus, develops at times the striped color phase. Variations in color as well as in coloration are indicated in our field notes, which we now give.

1. Reef southeast of Cape Johnson, north of La Push, Washington.—Dusky olive, clouded and reticulated with sooty, becoming blackish along back, and pinkish on abdomen and lower side of head.

2. Reef a short distance south of last one.—Burned amber, becoming blackish on margin of dorsal fin and on anal fin; belly abruptly silvery; pectoral pinkish, but sooty on and near middle of lower lobe.

3. Reef opposite Quillayute Needles, near La Push.—Olive brown, becoming silvery on belly, and blackish on and toward dorsal and anal fins and toward caudal base; posterior edge of dorsal and caudal pinkish; the latter with irregular cross bars; pectoral pinkish, becoming black toward base dorsally, and toward tip of lower lobe.

4. Reef at Ecola Rocks, Clatsop County, Oregon.—Young: sooty on top of head and on dorsal and anal fins, and near base of fins; other parts of tail largely clouded and punctulate; belly and throat largely clear; caudal fin transparent, with slight pinkish tinge, and with short dashes on upper and lower margins.

5. Same reef.—Half-grown: flesh-colored, becoming pinkish about mouth; dorsal and anal blackish; tail behind anterior fourth clouded with olive, pinkish and sooty; caudal pink, blotched with dusky; pectoral pink, becoming darker toward base and blackish along upper border and middle of produced lobe.

6. Yaquina Head, Oregon.—Semitransparent, whitish on lower side of head and on abdomen; grayish brown elsewhere on body, becoming blackish brown on anterior back forward to between eyes; dorsal and anal dusky, except near anterior and posterior ends; caudal whitish, with traces of bars; pectoral not dark on middle of lower lobe.

7. Same reef.—Grayish brown, becoming blackish toward dorsal and anal bases; body and head streaked with lighter and dark; some dark on pectoral lobe.

8. Reef between Cape Arago Light and Sunset Cove, Oregon.—Pale pinkish to blackish; plain to streaked.

9. Reef of Point St. George, near Crescent City, California.—Young: upper part of head and trunk and all of tail region gray, with traces of very narrow olive cross markings, which become quite distinct posteriorly; similar lines, also distinct, radiate from the eye; first dorsal dusky olive, with transparent border; second dorsal with narrow vertical bars anteriorly, becoming transparent toward the clear caudal; anal with irregular markings medially, especially along the base; belly, throat and paired fins unpigmented.

10. Same locality.—Young: in general dusky olive, indefinitely spotted and reticulated with darker posteriorly, becoming darker and more

uniform on top of head; cheeks and chin with clear spots and streaks; branchiostegals, gular region and disk abruptly paler, unpigmented; pectoral fins dusky, becoming lighter and flushed with red toward the pelvic disk; dorsal and anal blackish with a narrow, clear margin; caudal clear, except for wavy subvertical bars and lines of olive.

LITERATURE CITED

Ayres: On two species of *Liparis*. Proc. Calif. Acad. Nat. Sci., *1*, 1854-1857: 22-23. 1855

Bean, B. A., and Weed, A. C.: Notes on a collection of fishes from Vancouver Island, B. C. Trans. Roy. Soc. Canada, Ser. 3, *13*, 1919: 69-83, pls. 1-4. 1920

Burke, Victor: Revision of the fishes of the family Liparidae. Bull. U. S. Nat. Mus., *150*: 1-204. 1930

Evermann, Barton Warren, and Goldsborough, Edmund Lee: The fishes of Alaska. Bull. U. S. Bur. Fish., *26* (624): 219-360. 1907

Garman, S.: The Discoboli. Mus. Comp. Zool., *14* (2): 1-96, pls. 1-13. 1892

Gilbert, Charles Henry: The ichthyological collections of the U. S. Fish Commission Steamer Albatross during the years 1890 and 1891. Rept. U. S. Fish Comm., 1893; 393-476, pls. 20-35. 1896

Gilbert, Charles Henry, and Burke, Charles Victor: Fishes from Bering Sea and Kamchatka. Bull. U. S. Nat. Mus., *30*, 1910: 33-96. 1912

Gilbert, Charles H., and Thompson, Joseph C.: Notes on the fishes of Puget Sound. Proc. U. S. Nat. Mus., *28*, 973-987. 1905

Günther, Albert: Catalogue of the acanthopterygian fishes in the collection of the British Museum, *3*, 1861: 1-586. 1861

Jordan, David Starr, and Evermann, Barton Warren: The fishes of North and Middle America. Bull. U. S. Nat. Mus., *47* (2-4): 1241-3313, pls. 1-392. 1898 to 1900

Jordan, David Starr, and Starks, Edwin Chapin: The fishes of Puget Sound. Proc. Calif. Acad. Sci., Series 2, *5*: 785-855, pls. 76-104. 1895

Soldatov, V. K., and Lindberg, G. J.: A review of the fishes of the seas of the far east. Bull. Pacific Sci. Fish. Institute, *5*: 1-576. 1930

Starks, Edwin Chapin: List of fishes collected at Port Ludlow, Washington. Proc. Calif. Acad. Sci. *2*: (6) 549-562, pls. 74-75. 1896

Steindachner, Franz: Ichthyologische Beiträge (III). Sitzb. Akad. Wissensch., 1875: 29-96, pls. 1-8. 1875

Stability of Land and Water Areas in the Southwest Pacific

By P. MARSHALL, M.A., D.Sc.
Wellington, N. Z.

We who come from the islands of New Zealand are extremely interested in all questions relating to the transience or permanence of island areas and the relations of islands to other lands in the past.

This subject involves, of course, so much of the unknown and perhaps of the unknowable that it has attracted many scientific men in the past. Not geographers only, but geologists, zoologists, botanists, molluscologists, entomologists and even lumbricologists, besides other specialists, have contributed ideas based upon the facts that study of each individual science has revealed.

Of recent years study of this question has been somewhat stimulated by the publication of the able work of Wegener. The theory of drift of the continents as expounded by him has attracted many enthusiasts and has gained many supporters. The question as to the extent to which it applies to Australia and New Zealand may well be considered by geographical students in both of these countries.

Unfortunately, Wegener makes very little mention of the relation between Australia and New Zealand. He states that a spiral movement of flow of sima is shown in the Fiji Islands. "Its formation seems to me to be connected with the alteration of movement which Australia underwent when it ruptured its last connection with Antarctica, and began its still recognizable movement towards the

north-west and left the New Zealand festoon behind." (Wegener, A., "The Origin of Continents and Oceans," page 143.) He also (l.c., p. 70) quotes Wilckens: "The south-westerly curve of the mountain system of New Zealand (the so-called Otago Saddle) appears to be cut off suddenly on the east coast of the South Island. This termination is not natural, but depends without doubt on a fracture. The continuation of the system can only be sought for in one direction, that of the cordillera of Graham Land, the Antarctic Andes."

"All this can be explained by the displacement theory as due to the fact that New Zealand was formerly the eastern margin of the Australian cordilleras."

On the generalized maps, New Zealand is represented as firmly united with Australia in the Eocene, while in the Older Quaternary the south portion is closely adjacent to the Australian coast.

Gregory states: "Australia is generally accepted as having once continued eastwards to Fiji and New Zealand."

Von Ihering's "Archipacificis" extends across the Central Pacific from America to Asia in the Upper Cretaceous period.

With these very recent statements of well-known authorities before us, I may be permitted to start with such a comparison of these two countries as my knowledge allows me to offer.

A comparison based on the surface geography may appear of small value; yet something may be said from this standpoint.

The Australian mountain range is close to its east coast, while in New Zealand for two-thirds of its length at least the mountains are close to the west. In Australia there is a vast extent of western plains formed, I understand, mainly of horizontal beds of Upper Cretaceous age, perhaps partly of terrestrial origin. In New Zealand the eastern plains are formed of fluviatile gravels, and in the North Island, too, the eastern hilly country of young Tertiary rocks has a nature wholly different from that of any part of Australia. New Zealand has outstanding volcanic cones which are represented in Australia by small volcanic puys comparable with the cones in Auckland and in the Bay of Islands. In New Zealand much of the North Island is overwhelmed by masses of rock formed of acid volcanic tuffs, and in large part pumice, but often fine-grained and compact, due then to the emission of "nuées ardentes" more extensive and of higher temperature than that which overwhelmed St. Pierre in Martinique; and even mightier than the terrible outburst that covered the floor of the Valley of Ten Thousand Smokes at Katmai in Alaska more than 100 feet deep.

These volcanic emissions submerge the axis of the main mountain range and cover much of its western and eastern slopes in the center of the North Island. In their broad features as thus outlined the Australian and New Zealand areas are different enough.

In detail, too, the differences are no less striking. On the continent white sandy beaches front so much of the coast; and the sand on the east side seems to be mainly derived from the old sandstones of Permian and Triassic age, which is now once more having an active life after so many ages of quiescence. I have previously shown that sand grains when unmixed with coarser material on a sea beach are so long lived as to be almost permanent.

Certainly in New Zealand, too, there are long stretches of white sand beaches, both in the South Island from Kaitangata to Oamaru, and in the North Island for 200 miles from Kawhia to the North Cape. The latter sands, however, are not formed of quartz grains only. With this mineral there is a large amount of water-clear feldspar crystals. This is derived from the pumice sands that are scattered so widely over the central part of the North Island.

Though always called pumice sands, this inflated volcanic glass actually forms a very small portion of the sand, for as

much as 70 per cent of the so-called pumice sand is formed of crystals of quartz and felspar.

The coasts of Australia show little of that terraced form which is so striking on most of the New Zealand coasts. At the south-west corner of New Zealand there is a series of three terraces—the highest perhaps 1,500 feet above sea level. South of Dunedin only one is present, 25 feet above the present level. North of Christchurch there are terraces almost all of the distance of 130 miles to Cape Campbell. In the North Island there are several marine terraces on the east side of Wellington, though two only and sometimes none on the west.

Hardly interrupted, except in Hawkes Bay, these terraces have their finest form near the East Cape. So, too, on the west coast near Wanganui they are clear and distinct again, though further inland, and have a wide extent.

How few are the terraces on the Australian coast! A rock shelf, not far above high tide level, which I and other New Zealand geologists, in days of daring, venture to say is not a terrace which indicates a higher sea level. The form of the two coasts is as different as the origin of the materials of the beach.

A large part of the central region of the North Island has wide areas of acid rocks. These occur in thick masses lying in almost horizontal beds. They have generally been called rhyolites, but are now recognized as being formed by those sand-flow eruptions. It is probable, however, that our rocks have been formed by immense and numerous "sand-flow" eruptions such as that at Katmai in Alaska. The immensity and devastating nature of these eruptions must have been truly awful.

Thus volcanic forms, structures, materials, and processes exemplify practically all phases of this activity, at once the most awe-inspiring, interesting, and in some respects, the most baffling of all events in physical geography, certainly a contrast with Australian conditions in these latest times.

These opposite coasts of Australia and New Zealand are thus different in their major geographic features, in the age of the rocks of which they are formed, in the structure of the rocks, in their composition, and in the structure of the modern strand. When such differences as these exist, of what importance is it that the curve of the two coasts happens to be such that it would seem as though the convexity of the one would nestle neatly in the concavity of the other? With contrasts great as these in the mind, it is hard to accept such ideas of the former union of Australia and New Zealand as are advocated by Wegener.

The Tasman Sea separates two strongly contrasted coasts and lands, wholly diverse in structure. This speaks strongly for the probability of the antiquity of that deep ocean basin, the so-called Tasman Sea, the floor of which is very uniformly 17,000 feet below sea level.

It has long been felt that the wide occurrence of felspathic sandstones or greywackes in New Zealand implied the existence of a granitic continent in close proximity to these islands. The fact that felspathic sands are now being carried down by rivers to the seashore from the "rhyolite" plateau in great quantity has not been recognized previously. It is now suggested that similar action in the Triassic and Jurassic periods would account for the wide occurrence of greywackes more satisfactorily than abrasion of a granitic continent. The remarkable freshness of the felspars and the suggestion of volcanic origin generally shown by them strongly supports this suggestion. Such an origin of the widely occurring greywacke rocks would obviously make New Zealand more self-contained than has previously been admitted.

Reliance is usually placed on the features of the fauna and flora, when attempts are made to define the insularity and age of land areas. This has been done repeatedly in regard to New Zea-

land. It is not intended here to review the large literature of the subject. It is not possible in a brief address. Comparisons of larger groups of animals and plants alone can be made.

Once again it is necessary to refer to the absence of all terrestrial mammalian life from the New Zealand fauna. The country has been separated from the rest of the world from before that period when Monotremes first lived in Australia and New Guinea. As we are yet ignorant when that period was, we must try to derive information from other groups of animals.

Of reptiles, the tuatara must have reached New Zealand along a continuous land connection. This type of reptile is of extreme antiquity. Of other reptiles there are two families of lizards only, and they have a world-wide distribution, and in this case may well owe their introduction to man. Compare this with the Australian reptilian fauna which has six families of lizards as well as tortoises and snakes. It thus appears that New Zealand has been separated since the reptilian groups developed. The Amphibia are represented by three families in Australia. In New Zealand there is a single species of frog not allied to any Australian type and belonging to a distinct family, which is not found nearer than Asia.

With the consideration of birds we enter rather different fields, for birds have means of distribution not possessed by the previous groups. It is, however, certain that the *Dinornis* with similar moas, and probably the *Apteryx,* did not reach New Zealand by flight. Not only is the sternum without a keel but no rudimentary wing bones of *Dinornis* have been found. That there were birds with a keelless sternum and rudimentary wings even in Cretaceous times, yet distinctly avian in their characters, is of course well known. Thus it seems that the moa may have reached New Zealand over land before the middle of the Mesozoic.

Fish have such special means of distribution across water stretches that they hardly need consideration in this connection. Many freshwater fishes have a larval or youthful stage in salt water and thus may be distributed across marine areas.

Of invertebrates, insects are obviously of great importance. They are known to be of extreme antiquity, but the distinctions between some of the recent groups have appeared in comparatively late times, though it is probable that all were well defined before the Cretaceous period. Insects, however, have great powers of distribution, and a land that has been isolated from its very birth is certain to have an insect fauna, small perhaps, and usually of such a character as to indicate that its members are waifs and strays. In these insular faunas, usually, many large families are represented by but one or very few species.

The work of Dr. Tillyard enables us now to form definite ideas as to the relation of the insect faunas of Australia and New Zealand.

Altogether in the insects there are 361 families, with a total of 37,080 species in Australia, of which 147 are absent from New Zealand, which has 8,210 species. On the other hand, there are but four families which include only 12 species which occur in New Zealand, and are not represented in Australia.

Tillyard recognizes nine different periods when the insect fauna of Australia was enriched and five periods when land elevations allowed of additions to the New Zealand insect fauna. Two of the latter additions were from Indo-Malaysia, and from the Antarctic in the Jurassic period.

Perhaps the most definite impressions are these apart, of course, from the absence of many families, which is due to the narrower limits of climatic conditions in New Zealand:

(1) Many of the families poorly represented in New Zealand include species that have a weak flight.

(2) Insects whose life habits involve the development of social communities, such as the

bees and wasps, have very poor representation in New Zealand.

(3) A very large number of families have a most limited number of species in New Zealand.

All of these three impressions indicate that the insect fauna of New Zealand largely consists of waifs and strays.

The occurrence of practically all the New Zealand families of insects in Australia shows that New Zealand has received no fauna from other lands in which Australia has not participated. On the other hand, the fact that New Zealand is wanting in so many large and widely distributed families of Australian insects surely proves that Australia has received many accessions to her insect fauna since the continent has been separated from New Zealand. The fact that the 361 families of Australian insects contain an average of 103 species, while the 214 in New Zealand have an average of 38 species only cannot be wholly due to the relative dimensions of the two lands.

Any ordinary observer is at once struck with the great contrast between the native flora of Australia and that of New Zealand.

It is astounding that two countries so relatively close should have such very different plant coverings, especially in view of the fact that in these times, when stress of storms has raised the dust from the Australian dry areas, some 100,000 tons has been known to have been deposited on the surface of New Zealand. In New Zealand, there are some important genera of plants which are absent or very poorly represented in Australia.

It would seem that the comparison of the flora leads to much the same conclusions as those derived from that of insect life. Australia must have received its leguminous plants, its Proteaceae and mainly its Myrtaceae subsequent to its last connection with New Zealand by way of the Melanesian Islands or by way of Antarctica. In other words, New Zealand has been separated from Australia for an extremely long time, actually before the Australian flora acquired its present distinctive character.

It is only among the mollusca that we have a record of past animal life in the two lands. A comparison of these indicates that as far back as the older part of the middle Tertiary, which is as far as the Australian records of this Cainozoic marine life go, there is the same great difference between the contemporary shells of Australia and New Zealand as exists at the present day. In other words, as we delve into the past, we do not find any evidence of a closer approach of the two lands than there is at present, at any rate since the Triassic period.

This inquiry then has led us to envisage the great physical contrasts of these lands on opposite sides of the Tasman Sea. In no respect is there a similarity in structure or history. The diversity in vertebrate life points to a separation of the lands in the far past. This is further emphasized by a comparison between the great and widely dispersed insect faunas. The astounding differences between the plant life of the two countries are in complete accord with the conclusions derived from the physical structure and the animal life.

It is not intended here to discuss the Wegener hypothesis in general, but it is well to consider briefly the view that is taken by geophysicists who are competent to consider it from a physical and astronomical standpoint.

Jeffreys and Hinks, among many others, state that though a disproof of the theory is not altogether possible, no support can be found for it from physical facts. Simpson supports it strongly, stating that this theory alone gives an adequate explanation of the extraordinary climatic changes of the past. It is, however, notable that Coleman, on the contrary, maintains that the bunching of lands around the poles negatives the possibility of the development of glaciation in high latitudes, and makes the genial climatic conditions of interglacial periods quite impossible. He is strongly supported

in every particular by Willis. Coleman also emphasizes the point that glacial conditions were world-wide, and developed on the mountains in tropical and warm climates at the same time as polar glaciation.

Thus there seems no alternative to the belief that these three units, Australia, New Zealand, and the Tasman Sea, may be regarded as stable and permanent features from the geographical standpoint at least, and perhaps from the geological standpoint as well.

The idea of Australia setting sail to the westward in the latest Tertiary times and leaving New Zealand behind is a fiction of the imagination. Appendages are not lost so easily.

It has often been maintained, and indeed demonstrated, that many New Zealand life forms have entered the country from the north by way of the relatively shallow water ridge passing through the Kermadec Islands, Tonga, and Fiji and the New Hebrides. It is an undoubted fact that many plants have reached New Zealand from the north and probably during the early and middle Cretaceous when the margin of New Zealand extended so far beyond its present bounds. There is likewise no doubt that many plants reached us from the south, perhaps about the same time.

Unfortunately, the island groups that have been mentioned on the northern submarine ridge contain no deposits that allow us to trace the migration of any organisms through them. Yet for the most part they have a respectable antiquity.

The Kermadec Islands, which lie 500 miles to the north-east of New Zealand, are formed of volcanic rocks only, and since some amount of activity is still displayed by them, they are presumably of comparatively recent age.

On the basis of the percentage of endemic species of plants, Oliver states that the Kermadecs are not as old as Lord Howe and Norfolk Islands, in which the endemic percentage is higher. The relative activity of agents of distribution and the geographic proximity of other lands are, however, neglected in this statement. The flora, however, is shown by Oliver to be more closely related to that of New Zealand than of Australia, as indeed would be expected. The age of the islands, however, is such that they cannot have been a link in this early Cretaceous extension of New Zealand to the north. Their fragmentary fauna shows that these islands have been apart from other lands since their very birth.

The Tonga Islands come next on the submarine ridge, which extends north from New Zealand. The majority of these islands consist of coral limestone, but in some of them there is igneous material and others are entirely volcanic. The islands lie within the tropics, and some of them have a considerable antiquity. Recently, fossils of distinctly Eocene age have been found in Eua, the most easterly member of the group. The limestones in which they occur are probably ancient coral reefs now long since emerged. At present we know nothing of the composition and age of the submarine ridge on which these islands stand. The foraminifera contained in the limestone and the absence of other kinds of rock suggest that these islands have been islands from the first. Their form does not suggest that they are the remnants of land once at a higher altitude, for in the lapse of time erosion would have produced features easily recognizable in the submerged remnants. There is no indication that these islands ever formed part of a larger land area.

The low elevation of the Tonga Islands and their situation within the tropics do not favor the occurrence of a fauna and flora which could have any close relation to those of New Zealand. There is no possibility of a mountain flora showing the interesting features of those that have been found in Tahiti and Hawaii and in Rarotonga.

Tahiti and the Society Islands are formed entirely of volcanic rocks, and,

though rising to an extreme height of 7,000 feet, they have an insufficient altitude to allow of the complete development of the mountain flora that has such a great interest in Hawaii. The form and erosion features of Tahiti suggest a younger age than those of Huaheine, Raiatea and Moorea, but, even so, the latter islands do not appear to have any great antiquity, as all the volcanic rocks are fresh, with unaltered minerals, though they often belong to species which are easily attacked by atmospheric agencies.

The flora on the mountains contains elements that have distinct similarities with that of New Zealand.

A notable occurrence is that of the peculiar composite genus Fitchia in Tahiti. The development of this genus Guppy regards as an evidence of great antiquity and as a proof that land has existed in this island group since the early Tertiary; *Dammara* and *Araucaria* of New Zealand, Norfolk Island, and Australia Guppy regards as dating their distribution to the Cretaceous. It is certainly a fact that in the Upper Cretaceous this type of plant actually existed in the North and South Islands of New Zealand.

In the Society group, we have no fossiliferous limestone to help us in estimating their age, though it is hoped that the island Makatea may yet give us some information.

The Cook Islands are partly of volcanic origin and in part are formed of limestone rock. Mangaia, the south-eastern member of this group, almost on the Tropic of Cancer, has a volcanic cone rising to 550 feet, but truncated by marine action, but this is surrounded by a ring of raised coral rock to a height of 190 feet, with a deep depression—the old lagoon of the coral reef between them. Here the old coral reef is definitely of Miocene age, and its form and structure are such as to prove that it has never been highly elevated and never submerged since that time. Rarotonga is entirely of volcanic origin. The higher hills of Rarotonga, which rise to 2,100 feet, have a mountain flora resembling that of Tahiti with *Sophora, Metrosideros, Coprosma,* and *Elaeocarpus,* which give it a distinct flavor of the New Zealand vegetation, though distant 1,600 miles from it. The Tahitian genus Fitchia occurs here, too, as well as in Mangaia, but it has not been found on the other islands of the Cook group, probably because their altitude is not sufficient, though at Rarotonga the tree is found on the south side of the island almost at the sea level. On the relatively low island of Mangaia, *Sophora* and *Metrosideros* occur, though the area above 500 feet is so small.

The similarity of mountain floras in Polynesia and their general resemblance to that of New Zealand is a most notable feature, and might well suggest to many minds the probability that the islands mark the former mountain peaks of a once continuous land.

It must, however, be remembered that we have as yet but a fragmentary knowledge of methods of plant distribution. The numerous petrels and shearwaters of the Pacific—once, in all probabilities, far more abundant than now—are burrowing birds amongst the vegetation of mountains in all of the groups of islands. They are rapid-flying and active birds, and may well carry the glutinous seeds of *Coprosma* and *Coriaria* over great distances. It has, however, not yet been shown that these petrels journey from one island to another. Observations rather indicate that they adhere somewhat rigidly to their home island.

All details in regard to plant distribution offer difficult problems, and in any particular instance may be the result of rare accidents. Gregory has recently stated that the indications given by plants are so confusing in regard to distribution and the previous existence of lands now submerged that they must be discarded.

The fauna of the islands in this southwest Pacific offers many interesting points.

In Rarotonga, all the land birds except

the Polynesian long-tailed cuckoo, which is notably migratory, and a dove, seem to have been endemic. They are, unfortunately, now almost extinct. In Mangaia, a strident kingfisher is abundant near the coast, and a small canary-like bird—locally called oio—is often seen. In Atiu there is a swallow commonly seen in the evening, and among the coconut palms a woodpecker is general. In Tahiti a swallow is often seen in the upland valleys. Right away in the Henderson Island there are three endemic birds, including a crake and a parakeet. The Didunculus of Samoa and the Serresius of the Marquesas, and perhaps an allied form in Tahiti, indicate long separation.

It is, I think, clear that the land birds of these islands are species whose ancestors have by some chance reached them from distant lands, and that each of them has received its fauna independently.

A comparison of the few lizards that are found has not yet been made, but it is extremely probable that the few species that are found owe their presence to accidental transport in canoes.

The insect life of these islands is as yet almost wholly unknown, and the mollusca are as yet largely unclassified.

In considering the dispersal of plants by natural agencies, we are, I fancy, somewhat too apt to place over-confident reliance on the observations of natural phenomena that have been made during the extremely brief period of human records in this region. It is, indeed, possible that within the immense ages of even the later Tertiary time there have been moments or occasions when natural conditions have conspired together to produce results which completely surpass all that have been observed in the last hundred and fifty years.

Thirty years usually elapse between that association of conditions which is necessary to transport Australian dust to New Zealand. We have no right to assume that we have witnessed the extreme condition that a union or conspiracy of atmospheric forces can produce. It is indeed possible that at times dispersion vigor may be many times as great as has ever been experienced during man's knowledge of this region, and that at intervals which, measured in years, may seem enormous, but, measured by nature's scale, are but minutes, conditions may at particular times conspire to bring birds or insects, live seeds of plants or larvae of mollusca, over distances that it would seem impossible for them to traverse.

It is not necessary, to my thinking, that there should be any nearer approach between Australia and New Zealand in order to explain the presence of identical or closely related species of *Myoporum, Coriaria, Leptospermum,* and the many other genera common to the two lands.

The islands that lie to the south of New Zealand, often called the sub-Antarctic Islands, include the Suares, Auckland, Campbell, Antipodes, Macquarie, and Bounty Islands, all situated on a submarine plateau not deeply submerged. The flora is closely related to that of New Zealand; though, with the aid of climatic conditions, development has proceeded so far that species belonging to genera widely spread in New Zealand are represented by different forms in these islands.

It is particularly noticeable that the recent mollusca of 208 species are overwhelmingly New Zealand types. There is certainly no closer approach to the South American mollusca than in New Zealand itself. The Lepidoptera, too, are closely similar to those of New Zealand. The earthworms do not appear to indicate any special relation to those of South America.

It is interesting to note in this connection that the flora and fauna of Seymour Island—which is in the Antarctic area opposite to Patagonia—of Tertiary and Cretaceous times appear to have a distinct resemblance to the fauna and flora of similar times in New Zealand.

Summary: Wegener, Gregory, and von Ihering have recently stated that Australia and New Zealand have been united in relatively late geological times.

The configuration of the land surfaces of Australia is shown to be completely different from that of New Zealand. The materials of the strand offer a great contrast.

The frequently terraced nature of the coast line of New Zealand is contrasted with the unterraced coast of Australia.

The structure of the rocks is very different in the two lands. In Australia, all rocks from the middle Palaeozoic to recent are but little folded. In New Zealand, all Mesozoic rocks are intensely folded, and even Tertiary rocks are often folded and even contorted. Recent volcanic action in New Zealand has no counterpart in Australia. The absence of mammals and extreme paucity of vertebrates, except birds, bespeaks long isolation and shows separation from Australia since at least middle or early Mesozoic.

Australian insects are widely different from those of New Zealand. In particular those with poor flight and those that have developed social communities are poorly represented in New Zealand.

Plant life is strongly contrasted. The forty most important genera in Australia are scarcely represented in New Zealand.

Eua in the Tonga group had coral reefs in the Eocene.

The flora of Tonga does not suggest that this island lay on the route along which the flora and fauna of New Zealand passed.

The Society Islands give indication of continuous isolation.

Mangaia, of the Cook group, has been in existence since the early Miocene, and has never been completely submerged and has never been large. The Kermadec Islands and the southern Antarctic islands are closely related to New Zealand in their flora and composition.

The facts summarized in this address show that the composition and structure of Australia and New Zealand are so strongly contrasted that no common origin can reasonably be suggested for the two lands. This contrast extends as sharply to the fauna and flora of the two lands.

The various island groups in the south-west Pacific lying to the south and east of New Caledonia and Fiji appear to have been isolated since their formation.

New Zealand has been separate from Australia at least for the period that has elapsed since that continent received its reptilian, amphibian, insect and mammalian fauna and the characteristic flora. This cannot well have been later than the early or middle Mesozoic.

A discontinuous chain of islands, at one time connected with Australia on the one hand or with Antarctica on the other and at other times with New Zealand, might explain the faunal and floral features of New Zealand.

Production of Honey in Hawaii

From "Honolulu Advertiser," November 19, 1934

The history of the development of the honey industry in Hawaii can be woven into a fascinating story of experiment, equal in interest if not in volume of production, to one of the major industries.

The first hives were introduced in Hawaii from California in 1857. Prior to this, several unsuccessful attempts were made to bring black bees around the Horn from New England. The birth of the industry dates back to the time when one Sunday afternoon St. John Gilbert and his brother captured a swarm of bees in a wooden box and later imported ten hives from California. Since that time beekeeping has grown into a considerable business on a commercial scale.

Italian bees were first brought to the islands around or about 1880 by the late Samuel G. Wilder. Two hives were bought in Los Angeles, sent to San Francisco and shipped down on the steamer *Lihue*. Islanders secured eggs from the queen Italian bees in these hives.

After reaching a certain point in the export trade there has been but little advance made in honey production for the market. Mainland shipments have shown some variation in pounds per annum, averaging from one and a half to two million pounds.

The source of Hawaiian honey is little known to the average person, as surprisingly few people are aware that the alga-

roba or kiawe tree furnishes the chief forage for the bees. The algaroba (mesquite) is an introduced tree and grows rapidly in the islands, more rapidly even than in Algiers and Italy. This tree makes a valuable forest cover for the semiarid lands near the ocean, and thrives in spite of scarcity of rainfall, and furnishes both shade and food for live stock.

There are about 80,000 acres of algaroba forests in the islands, which furnish very good bee pastures. The blossoms come from February to April. Island honey as an industry would not exist if it were not for these blossoms, as it is these pale yellow flowers, heavily laden with nectar, that furnish nourishment for the bees.

The rapid spread of the algaroba trees in the islands gave the islanders an opportunity to produce a different flavor of honey from that found on the mainland. The commercial possibilities were grasped by a few, and the principal apiaries in the territory are situated along the coast of the islands in the shelter of algaroba trees.

There are some flowers blossoming throughout the year in Hawaii and bees enough to produce over a million and a half pounds of honey and considerable high-grade beeswax. While the largest part of Hawaiian honey, classed as floral honey, is obtained mainly from the algaroba, nasturtiums and alfalfa, there are also other sources.

The busy bee gathers honey from the flowers of the ilima, lantana, guava, pili grass, rice, koa, ohia, eucalyptus, palm trees, sisal, fruit trees, vines and plants. The amount derived from these sources is not to be compared with the amount obtained from the blossom of the algaroba.

Ilima honey is of bright golden color and the flavor is good. Ohia honey is a beautiful amber and of very fine flavor as a table honey. It is equal to any mainland product.

Hawaiian honey consists of two distinct types; a floral product derived mainly from the algaroba, which compares favorably with the official definition of honey, and a honeydew product decidedly different in its chemical composition.

There are six different grades of honey, classified on a basis of color as follows: water-white, white, light amber, dark amber, amber and honeydew.

Pure algaroba or kiawe honey is nearly water-white in color, and solidifies or crystallizes soon after extraction and people who do not understand its composition fear that it has been adulterated with sugar. However, the color of the honey is very light and it is very pleasing.

Algaroba honey comes under the levorotatory honey. That is, algaroba honey is a real honey under the National Food Law which says that honey should be levorotatory, and should contain not more than 25 per cent ash, 25 per cent water, and not more than 8 per cent of sucrose. On the other hand, the honeydew honey is dextrorotatory. That is, when you place the real honey in a polariscope, it bends the ray of light to the left, while honeydew bends toward the right.

Honeydew is noncrystalline, usually dark in color, with an aroma similar to molasses. Honeys obtained from other flowers are dark and of poorer quality except from the lehua flowers which grow on the island of Hawaii.

Years ago, when honey producing was inaugurated on what was supposed to be a paying basis, that part of the product sent to the coast to be marketed was not favorably received. From that time on the beekeepers have steadily improved the quality of the honey product here. Entomologists and chemists have given much of their time to the study of Hawaiian honey, conducting experiments, etc. Reports from many analyses show Hawaiian honey pure and wholesome.

Four grades of honey are produced in Hawaii, viz., white, water-white, light amber and dark amber. Hawaiian honey blends well with mainland honey.